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PHYSICS.—*An electromagnetic theory of quanta.* F. RUSSELL BICHOWSKY, Johns Hopkins University. (Communicated by A. L. DAY.)

Several attempts have been made to modify the electromagnetic theory of Maxwell and Lorentz in order to make it consistent with the experimental facts which are the basis of the quantum theory. Most of these modifications have concerned the Lorentz equations for the electron, rather than the original Maxwell equations for the electromagnetic field. The reasons for this are: first, the feeling that the quantum effects were somehow tied up with special atomic mechanism, and second, because it was apparently necessary to keep the Maxwell equations to account for wave propagation of light and the ordinary equations of electricity and magnetism. On the other hand, there is some evidence that the underlying quantum mechanism, whatever it may be, is more general than any particular atomic structure but has to do with the field equations, the arguments for this being the same as those which led Einstein to the conception of light quanta.

The second point is susceptible to mathematical analysis. The electromagnetic theory is the embodiment of the following ideas: (1) the magnetic flux is some function of the circulation of electrical forces, (2) the electrical flux is some function of the circulation of magnetic forces. We shall use Heaviside units, and the Lorentz notation, except that we shall follow the uses of Gibbs for the vector operators. In this notation (1) and (2) become

$$\nabla \times f(\mathbf{h}) = \frac{1}{c}\dot{\phi}(\mathbf{d}) \tag{4}$$

$$\nabla \times \psi(\mathbf{d}) = -\frac{1}{c}\dot{\theta}(\mathbf{h}) \tag{5}$$

The constants $\frac{1}{c}$ and $-\frac{1}{c}$ appearing explicitly since electric forces are to be measured in electrostatic units and electromagnetic forces in electromagnetic units, and the right hand screw convention is to be used to fix sign.

Equation (1) of Maxwell is a definition and may be kept unchanged without loss of generality

$$\mathbf{c} = \dot{\phi}\,(\mathbf{d}) \tag{1}$$

Equations (2) and (3) of Maxwell are usually thought to express the experimental restriction that there be no permanent uncompensated charges or free magnetic poles in the space considered, and may, in accordance with this mode of thought, be put in the form

$$\nabla \cdot \psi\,(\mathbf{d}) = 0 \tag{2}$$

$$\nabla \cdot f\,(\mathbf{h}) = 0 \tag{3}$$

At first sight, these expressions appear to be merely a definition of uncharged space, but this interpretation is not free from possible difficulties, for if we consider free space through which an electromagnetic disturbance is passing, the electric and magnetic energy at each point is finite. Now the only apparent way to build up electric and magnetic energies in space is to separate neutralizing charges in space by producing what is called dielectric displacement, or by creating fugitive electric charges in time. Now, the first point of view involving dielectric displacement has the advantage that it is consistent with the atomic structure of electricity, but it has the disadvantage that since both positive and negative electricity are assumed always present even in uncharged space, uncharged space is given an energy and mass content for which evidence is lacking or directly opposed. The second point of view assumes the generation of fugitive electricity, which is certainly not orthodox, but leaves uncharged space empty. It may be shown, however, that both points of view lead to mathematically equivalent results, though they suggest different interpretation. We may, therefore, keep to the conventional point of view as expressed in equations (2) and (3).

We now have assumed four general equations of which the Maxwell equations are special cases where the undetermined functions f, ϕ, ψ, and θ are each equal to 1. Our problem now is to find what restriction on the form of these functions is necessary to account for those facts of optics, electricity and magnetism which are successfully

accounted for by the special Maxwell function. Examination shows that, as far as pure optics is concerned, all the equations for velocity, refraction, reflection, polarization, and interference depend on the assumption that there are solutions of the electromagnetic equations of the form:
Dalembertian $(\chi) = 0$, i.e.,

$$\nabla^2 \chi - a^2 \ddot{\chi} = 0 \tag{6}$$

Where χ may be any function of the electric and magnetic force separately, and where a^2 for free space equals $\frac{1}{c^2}$. That, as far as optical theory is concerned, χ may be taken to be an indetermined function of $\mathbf{d}$ and $\mathbf{h}$, may be proven by going through the proof for the ordinary equations of optics, but may be seen intuitively from the fact that the equations of pure optics do not explicitly involve electric and magnetic forces, the special form used in the electromagnetic equations cancelling out in the course of the proof of the optical equations. In order to derive equations for the effect of known magnetic and electric fields on optical phenomena, it is obvious that χ must be determinate, but it is significant that it is just in such equations that the Maxwell theory shows the first sign of breaking down.

Let us now assume that equation (6) represents the facts of optics and let us see what restriction this places upon the undetermined functions f, ϕ, ψ and θ. Reversing the proof by which the Dalembertian $(\chi) = 0$; $[\chi = \mathbf{d}; \chi = \mathbf{h}]$ is shown to be a solution of the Maxwell equation, it may be shown that $f = \theta$ and $\phi = \psi$. In other words, any function of $\mathbf{h}$ and $\mathbf{d}$ substituted in the Maxwell equations will lead to a solution consistent with all purely optical phenomena, provided only the derivatives of the same functions are substituted for $\dot{\mathbf{h}}$ and $\dot{\mathbf{d}}$ respectively. Maxwell's equations, therefore, are by no means the only electromagnetic equations which will lead to the facts of optics.

There is, however, one other restriction which may be put on the equations of the electromagnetic field, namely that they be consistent with the principle of least action. From all that is known experimentally, this is not a necessary restriction and may not be legitimate, in fact, but it is certainly convenient to make this assumption as it allows the general methods of dynamics to be applied to electromagnetics. There is a difficulty, however. To make use of this principle it is necessary to set up separate equations for the kinetic and

potential energies of the field, that is to say, the part of the energy which depends on generalized velocities and that which depends on positions alone. In the ordinary theory it is known that the kinetic energy arises exclusively from the magnetic forces, and is given by the equation $T = \frac{1}{2}\int \dot{\Xi}^2\, ds$, where $\Xi = f(\mathbf{h}) = \mathbf{h}$ [in the ordinary theory]. Similarly, the potential energy W depends exclusively on the electric force, and is given by the equation $W = \frac{1}{2}\int \mathbf{d}^2\, ds$. There is no apparent reason why this should be the case here since it might well happen that our function $f(\mathbf{h})$ might contribute both to the kinetic or potential energy; similarly for $\psi(\mathbf{d})$. It may be shown, however, by substituting $\Xi = f(\mathbf{h})$, integrating equation (5) in respect to the time, taking the scalar product of the variation of Ξ and the function, for a real and slightly varied path between A and B and integrating over the path, discarding the integrated parts, employing equation (4) and integrating again, that if the principle of least action holds, the difference between the kinetic and potential energy must be in the form $\int (T - W)\, ds = \frac{1}{2}\int \{\pm \dot{\Xi}^2 \mp \psi^2(\mathbf{d})\}\, ds$, the signs being opposite but undetermined. Now, if, as we shall assume $f(\mathbf{h})$ is a function of the wave length and any term of the expansion contributes to the kinetic energy, all the terms must, but at long wave lengths $f(\mathbf{h})$ must reduce to $\mathbf{h}$, in order to account for the experimental fact that Maxwell's equations hold for static or slowly changing fields, therefore $T = \frac{1}{2}\int \dot{\Xi}^2\, ds$ and similarly $W = \frac{1}{2}\int \psi^2(\mathbf{d})\, ds$.

It will now be convenient to define the magnitude of two new vectors $\mathfrak{D}$ and $\mathfrak{H}$ by the equations $f^2(\mathbf{h}) = \mathbf{h}^2 - \mathfrak{H}^2$ and $\psi^2(\mathbf{d}) = \mathbf{d}^2 - \mathfrak{D}^2$. In other words we have added a scalar corrective function to the Maxwell equations. There appears to be no experimental test which will fix the direction of the vectors $\mathfrak{H}$, and $\mathfrak{D}$, but it will be convenient later to assume that $\mathfrak{H}$ has the same direction as $\mathbf{h}$ and $\mathfrak{D}$ as $\mathbf{d}$. In these terms our fundamental equations become

$$\nabla \cdot (\mathbf{d}^2 - \mathfrak{D}^2)^{\frac{1}{2}} = 0 \tag{2}$$

$$\nabla \cdot (\mathbf{h}^2 - \mathfrak{H}^2)^{\frac{1}{2}} = 0 \tag{3}$$

$$\nabla \times (\mathbf{h}^2 - \mathfrak{H}^2)^{\frac{1}{2}} = \frac{1}{c}\frac{d}{dt}(\mathbf{d}^2 - \mathfrak{D}^2)^{\frac{1}{2}} \tag{4}$$

$$\nabla \times (\mathbf{d}^2 - \mathfrak{D}^2)^{\frac{1}{2}} = -\frac{1}{c}\frac{d}{dt}(\mathbf{h}^2 - \mathfrak{H}^2)^{\frac{1}{2}} \tag{5}$$

which are the same as Maxwell's except that $(\mathbf{h}^2 - \mathfrak{H}^2)^{\frac{1}{2}}$ is substituted for $\mathbf{h}$ and $(\mathbf{d}^2 - \mathfrak{D}^2)^{\frac{1}{2}}$ for $\mathbf{d}$ everywhere. Using these equations we

obtain by differentiation an equation for the energy flux of an electromagnetic field

$$(8)\quad \frac{d}{dt}\left\{\tfrac{1}{2}\int(\mathfrak{d}^2 - \mathfrak{D}^2 + \mathfrak{h}^2 - \mathfrak{H}^2)\,ds + c\int(\mathfrak{d}^2 - \mathfrak{D}^2)^{\frac{1}{2}} \times (\mathfrak{h}^2 - \mathfrak{H}^2)^{\frac{1}{2}}\,ds\right.$$

The first integral is the expression for the energy of an electromagnetic field; the second, corresponding to the Poynting vector of the Maxwell theory, represents the flux of energy across the arbitrary boundaries of the field. The total expression obviously corresponds to the Maxwell expression for the conservation of energy, but the energy E is now equal to the quantity which would be calculated from Maxwell's expression E_c but

$$(9)\quad E = E_c - \tfrac{1}{2}(\mathfrak{D}^2 + \mathfrak{H}^2)$$

the flux being similarly

$$(10)\quad S = c\,(\mathfrak{d}^2 - \mathfrak{D}^2)^{\frac{1}{2}} \times (\mathfrak{h}^2 - \mathfrak{H}^2)^{\frac{1}{2}}$$

These expressions have the property of allowing zero energy density and zero radiation in fields where both the electric and magnetic forces are finite. They also show that if the classical (Maxwell) expression is taken as representing the energy, energy is not conserved, though it is with the new expression for the energy. Energy thus defined, since it was obtained by the use of the principle of least action, obeys the Hamiltonian equations, and its distribution is given by the equation

$$(11)\quad \partial E = \alpha\, e^{-\beta\{E_0 - (\mathfrak{D}^2 + \mathfrak{H}^2)\}}$$

where β must equal $1/kT$ since the equation must reduce to the Maxwell distribution law for the case of perfect gases. Equipartition, however, does not hold except in a modified sense, the average value of the energy of a degree of freedom of radiation being equal not to $\overline{E}_e$ but to $\overline{E}_c - \frac{1}{2}(\mathfrak{D}^2 + \mathfrak{H}^2)_{aver}$, where $E_c = kT$ is the average energy of a gas particle.

Now the energy of a radiation field may be expressed as a sum of terms (one for each degree of freedom) of the form $A\nu$ where ν is the frequency of a simple harmonic component of the electromagnetic wave. The energy per degree of freedom therefore can be put in the form $E = E_c - h\nu$, where h, as far as theory goes, is a constant in time, but adjustable for different frequencies; but we shall immediately see that within the experimental limits of the Planck radiation law, h is a constant for all wave lengths, and in fact is equal to the Planck's constant.

We may now calculate the equilibrium distribution between light waves of such energy and a perfect gas. The condition for equilibrium is

$$\bar{\mathrm{E}}\,\delta\,\mathrm{E} = \bar{\mathrm{E}}_0\,\delta\,\mathrm{E}_0$$

Substituting in our formulae (11) and (12) and using the usual formula for the energy of a gas molecule, we obtain

$$\bar{\mathrm{E}}\,e^{-\beta\,\mathrm{E}} = (\bar{\mathrm{E}} + \mathrm{h}\nu)\,e^{-\beta\,(\mathrm{E}+\mathrm{h}\nu)}$$

or

$$\mathrm{E} = \frac{\mathrm{h}\nu}{e^{\frac{\mathrm{h}\nu}{k\mathrm{T}}} - 1} \tag{13}$$

which is Planck's familiar equation, but it is now derived in an entirely rigorous manner from the fundamental laws of mechanics with the aid of a self-consistent electromagnetic theory. It will be noted, moreover, that we have made use of no discontinuities such as are involved in the ordinary quantum proofs, nor have we made use of subsidiary assumptions of atom structure, or phase space, or special probability functions. Indeed, we have not found it necessary that the energy of a light wave is a multiple function of the wave length of the type n h ν, n appearing nowhere in the proof. If, however, we had used the classical expression for energy and distribution, in order to make these equations consistent with Planck's law, the energy of a monochromatic light wave must vary discontinuously with the intensity, being of the form n h ν. However, this expression for the energy of a light wave is known to be inconsistent with general dynamical principles.[1] The remaining important expressions for the energy of a light wave, namely the Stefan-Boltzmann equation and the Maxwell equation for light pressure, follow directly from our equations by any of the usual proofs, the former also by direct integration of the Planck equation.

Now let us consider the radiator. It is clear that in order for a system containing moving charges to radiate the electric and magnetic forces (due at great distances mostly to accelerations) it must suffice to give the modified Poynting vector a value greater than zero. The vector product of $\mathbf{d}_r$ and $\mathbf{h}_r$ (where $\mathbf{d}_r$ and $\mathbf{h}_r$ are that part of the electric and magnetic forces which, on the Maxwell theory, contribute to the radiation) must be greater than hν, where ν is the frequency of emitted light. Therefore, that part

[1] BICHOWSKY, Phys. Rev. 11: 58. 1918.

of the energy of the electromagnetic field due to $\mathbf{d}_r$ and $\mathbf{h}_r$, e.g. $\frac{1}{2}\int(\mathbf{d}_r^2 + \mathbf{h}_r^2 - \mathfrak{D}_r^2 - \mathfrak{H}_r^2)\,\mathbf{ds}$, must equal zero for states in which the radiation is zero, such states we will call steady. There will generally be an infinite number of such states since both E_{r_0} and $\mathfrak{D}_r^2 + \mathfrak{H}^2$ are variables, and for all of them, except those containing no accelerations the radiation from which is of infinite wave length, E_{r_0} will have a finite value. Suppose we have a system in such a stationary state, with the classical energy $E_{r_{ca}}$, then $E_{r_{ca}} - \mathfrak{E}_{r_a}$; suppose it now absorbs radiation of the frequency ν. The energy absorbed from the small fraction of the wave surface available, calculated in the present way we will suppose to be P, where P is a quantity, we can make as small as we please by decreasing the intensity of the light. The contribution of this small amount of energy to the energy of the system will be $\Delta E_c - h\nu = P$. The system after absorption of energy has the energy $P = E_{ca} + \Delta E_c - \mathfrak{E}_a - h\nu$; it will, therefore, differ only a vanishingly small amount from the new non-radiating state $E_{cb} - \mathfrak{E}_b = 0$ where $\mathfrak{E}_b = \mathfrak{E}_a + h\nu$, therefore $E_{cb} - E_{ca} = h\nu$ which is Bohr's frequency condition.

Let us now suppose we have a system in such a displaced steady state and let it radiate. Since the new state is steady it will not radiate until it has gained an extra energy Q. It will now radiate its classical energy, changing from $Q + E_b$ to E_a the total energy given out being Q. Its wave length, moreover, will be given by the equation $h\nu = E_{cb} - E_{ca}$. Now, in order for conservation of energy to hold

$$-\int_b^a Q\,dt = \int_a^b P\,dt + \int_a^b P_a\,dt$$

where $\int_a^b P_a\,dt$ is the energy absorbed from neighboring atoms during the transition $A \rightarrow B$. These last integrals are independent, since at least theoretically all neighboring atoms can be removed to a double order of infinite distance. Therefore the number of transitions must be proportional to the amount of light per unit time per unit area.

It will be noted that the above proof of the Einstein-Bohr frequency condition tells us nothing about the frequency of the periodic motions of the electron in their stationary states. We can, however determine this connection for any particular model most simply by consideration of the moment of momentum. This quantity η, which is conserved, is given by the equation $\eta = \frac{1}{c}\,\mathbf{r} \times (\mathbf{d}^2 - \mathfrak{D}^2)^{\frac{1}{2}} \times (\mathbf{h}^2 - \mathfrak{H}^2)^{\frac{1}{2}}$ or $c\eta_u = \frac{Ec\omega}{\omega} - 2\pi h$, where $Ec\omega$ is the classical energy of a system with the

intrinsic frequency. Each possible transition is therefore equivalent as far as classical energy and impulse goes to that of a system of classical oscillators of the same constitution as the real system, but on a scale such that the energy and momenta are ΔE and $2\pi h$ instead of E and η. Now, since momentum and energy and constitution define a system completely, our system of virtual oscillators will have all the dynamic properties of the real system, not as an approximation, but exactly. It may thus be used to calculate frequency polarization, relative intensity, dispersion mean period of life, the results being exactly of the classical type except ν is to be substituted for ω, ΔE for E and $2\pi h$ for η.

Let us now consider the possible mechanical constitution of systems in the stationary state. Since the component of the radiation field of the same frequency as the motion of any electron must be zero, the field is conservative and must possess potential, a result which is consistent with the results of Fues[2] and Urey,[3] though unexpected according to the ordinary quantum theory. However, when it comes to the calculation of such potential, the problem is less simple. If the field is stationary, as in the case of the two bodies in a stationary external field, the only forces which with a constant position of the electron change with the time, are those due to radiation, and for stationary states these cancel out. We may, therefore, compute the impulse moment by the ordinary methods of dynamics and solve for the motions, putting the moments of each electron equal to nh, e.g., we can use the classical equations

$$\omega_\kappa = \frac{\delta\, Ec}{\delta\, J_{c\kappa}};\quad 2\,\overline{T} = \Sigma\, J_{c\kappa}\omega_\kappa;\quad J_{c\kappa} = nh;\quad [\kappa = 1, 2, 3]$$

where J_κ is the impulse moment and ω_κ the intrinsic frequency of rotation, of the electron, of the perihelion, and of the plane. These equations are seen to be identical with Bohr's formulation of the general quantum conditions, but by our proof they could only be expected to be valid in stationary fields, since the expression for magnetic and electric forces, according to the present view, contains the terms $\mathfrak{H}$ and $\mathfrak{D}$ which are functions in periodic systems of the frequency (in non-periodic systems of the accelerations). The general expression for non-radiating systems which would be expected from our equations would be

[2] FUES, Zeit. f. Physik. **11**: 364; **12**: 1; **13**: 211; **21**: 265.
[3] UREY, Phys. Rev. **25**: 241. 1925.

$$\omega_\kappa = \frac{\delta E}{\delta J_\kappa}; \quad J_\kappa \omega = \overline{2T}; \quad J_\kappa = 0$$

all the quantities being calculated according to the new electromagnetic equations.

Unfortunately, this formulation gives us no definite solution of the three-body problem in terms of known constants, for the values of $\mathfrak{H}$ and $\mathfrak{D}$ are unknown though one-half the sum of their squares is known to equal $h\nu$. In general, the solution must be different from that, assuming the ordinary law of force, because the magnitude of the periodic forces acting on an electron due to the changing relative position of the other electrons, would be different according to the present theory to that calculated from Coulomb's law. If, however, $\mathfrak{D} = 0$, this difference of the motion, due now exclusively to the change in the expression for the magnetic force, would be small since magnetic forces due to electron motion in general contribute but little to the total motion, the calculation reducing in this case, except for a small correction (of the order of the relativity effect), to the type of model investigated by Kramers. In the probably impossible case $\mathfrak{D} = h\nu$ there would be no perturbing perodic electric force on the motion of one electron due to the motion of another of the same frequency, even though the rotation was of different sense. This might lead, for example, to the model of a helium atom with the two electrons rotating in opposite senses, in equal circular orbits in parallel planes. Probably the true expression for $\mathfrak{D}$ and $\mathfrak{H}$ is not as simple as either of these cases, but it might still be reasonably expected that pairs of orbits might be found in which the perturbing effect of one on the other would not be large, even though the rotation was of opposite sense, a requirement which seems necessary to account for the low magnetic moment of certain atoms containing even numbers of electrons.

MINERALOGY.—*Boulangerite from the Cleveland mine, Stevens County, Washington.*[1] EARL V. SHANNON, U. S. National Museum.

Within recent years the mineral boulangerite, heretofore considered rare, has been found by the writer to be perhaps the commonest of the lead-antimony sulphosalts. Its occurrence in two important districts in Idaho, one in Montana, and one in Bolivia have been described[2] and it has since been found in ores from additional mines

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] E. V. SHANNON, Proc. U. S. Nat. Mus., **58**: 589-607. 1920.

in these regions and from Lower California. Another locality which came to notice a year or so ago is the Cleveland mine in Stevens County, Washington, where this mineral is one of the major constituents of a lead-silver ore occurring in lens-shaped bodies in fractured and brecciated zones in dolomitic limestone.[3] The Cleveland mine is located 18 miles by road west of Springdale, a town on the Great Northern Railway. In some bodies of ore the boulangerite is the most abundant mineral and it is prominent in most of the ore. The associated primary sulphides are galena, sphalerite, and arsenopyrite. Secondary minerals formed by the oxidation of these include cerusite, anglesite, mimetite, bindheimite, valentinite, and scorodite.

The specimens from this locality were received from Mr. Henry Fair of Spokane, Washington, to whom the writer desires to extend his thanks.

The boulangerite forms excellent specimens which apparently are available in quantity. The best one received weighs in excess of 2 pounds (1 kilogram) and is 90 per cent boulangerite. The mineral does not form free crystals but makes up columnar masses in which the parallel blades reach 10 centimeters in length. The color is light bluish lead-gray and the luster is metallic. The mineral becomes dull on exposure. Although there is evidently a tendency to cleavage, the larger blades are made up of fibers and no clean cut cleavage fragments can be obtained for measurement. The cleavages are in the vertical zone and there is none transverse to the fibers.

The material analyzed (U. S. Nat. Museum Catalog No. 94,514) was submitted to a metallographic examination, in polished section, by Mr. M. N. Short of the U. S. Geological Survey, who reports it pure except for the presence of about one tenth of one per cent. of pyrite. The microchemical reactions obtained with the standard reagents of Davy and Farnham are as follows: Strongly anisotropic; HNO_3 instantly tarnishes iridescent; with a slight effervescence; HCl fumes tarnish slightly—not always; KCN negative; $FeCl_3$ negative; KOH negative; $HgCl_2$ negative. These tests agree with those given for boulangerite by Davy and Farnham except that, where they describe the mineral as sectile, it is very brittle. The reaction—negative—with KOH immediately distinguishes this mineral from a jamesonite recently examined which quickly tarnishes dark brown with this reagent.

[3] O. P. JENKINS, Lead deposits of Pend Orielle and Stevens counties, Washington. Wash. Dept. of Conservation and Development, Div. of Geology Bull. **31**: 127–130. 1924.

The sample analyzed gave the results of column 1 of Table 1, while in column 2 is given the calculated composition agreeing with the formula of boulangerite, 5PbS. 2 Sb_2S_3, and in column 3 the theoretical composition of jamesonite according to Schaller's formula, 4PbS. FeS. $3Sb_2S_3$.

TABLE 1.—ANALYSIS OF BOULANGERITE

	I	II	III
Insoluble	0.40		
Lead	55.34	55.41	40.32
Iron	0.52		2.72
Antimony	25.30	25.72	35.10
Sulphur	18.08	18.87	21.86
Total	99.64	100.00	100.00

I. Boulangerite from Cleveland mine
II. Theoretical composition of Boulangerite
III. Theoretical composition of Jamesonite

Teher would appear to remain no doubt, from the foregoing comparison, of the agreement of the Cleveland mine mineral with the boulangerite formula and its distinct difference from jamesonite, to which mineral there is a strong tendency to refer all such lead sulphantimonites. The locality is of interest by reason of the excellence of its specimens of this mineral and it is to be hoped that they may be widely distributed in collections before the mine is exhausted.

ENTOMOLOGY.—*A new Rugitermes from Panama.* THOS. E. SNYDER, Bureau of Entomology, U. S. Department of Agriculture.

During the summer of 1924, Nathan Banks, of the Museum of Comparative Zoology, Cambridge, Massachusetts, visited the Canal Zone and localities in nearby Panama. Some time was spent collecting on Barro Colorado Island, Canal Zone, the site of the station of the Institute for Research in Tropical America.

In addition to many other insects, Mr. Banks collected an interesting series of termites, including one new species of the subgenus *Rugitermes* Holmgren. Banks also collected the odd termite *Armitermes* (*Rhyncotermes*) *major* Snyder, of Costa Rica and Honduras, on Barro Colorado Island. Panama is a new locality for this interesting species. He has courteously allowed me to examine this collection of termites.

Mr. Banks' collection brings the termite fauna of the Canal Zone and nearby Panama, up to 38 species, representing 23 genera or subgenera, 22 of which, representing 16 genera or subgenera, occur on Barro Colorado Island.

The new species is named "*isthmi*," in reference to the Isthmus of Panama, and is described as follows:

Kalotermes Hagen, subgenus *Rugitermes* Holmgren

Winged adult.—Often markedly bicolored, head and abdomen dark-colored, pronotum light-colored; in wings the median vein unites almost directly with the radial sector; antennae with 16–19 segments.

Soldier.—Similar to soldiers of *Kalotermes* and *Neotermes:* antennae with 13–18 segments.

The six described species of *Rugitermes* are all from South America; they are: *nodulosus* Hagen, *rugusus* Hagen, *occidentalis* Silvestri, *bicolor* Emerson, *flavicinctus* Emerson, and *magninotus* Emerson. *Kalotermes* (*Rugitermes*) *isthmi* Snyder is the first record of species in this subgenus occurring in Central America.

Kalotermes (*Rugitermes*) **isthmi**, new species

Winged adult.—Head very dark castaneous (almost blackish with reddish tinge), smooth, shining, longer than broad, sides almost parallel, rounded posteriorly, with scattered, long hairs. Postclypeus and labrum yellow, with long hairs; former, short but broad, latter broader than long and broadly rounded anteriorly. Eye black, not round, fairly large and projecting, separated from lower margin of head by a distance less than the diameter of the eye. Ocellus hyaline, projecting, suboval and at an oblique angle to the eye, almost touching eye.

Antennae dark castaneous, finely punctate, with 17 segments, segments become longer and broader (somewhat wedge-shaped) towards apex; third segment longer than second or fourth segments, subclavate; fourth and fifth segments subequal; last segment shorter, narrower and suboval.

Pronotum yellow or light yellowish brown, not twice as broad as long, broadest at middle, roundly emarginate both anteriorly and posteriorly; sides roundly slope (narrowed) posteriorly, with scattered long hairs.

Wings smoky dark brown, coarsely punctate. In forewing median vein unites almost directly with the radial sector; radial sector close to, parallel, and with six branches to costal vein, first three long and oblique, others short; cubitus runs parallel to radial sector above middle of wing to apex of wing, with 12–13 branches or sub-branches to lower margin of wing; subcostal vein unites with costa before the middle of the wing; seven irregular, transverse and crescentic branches between cubitus and radial sector (Fig. 3). In hind wing, median vein entirely absent; radial sector with two long and three short branches to costal vein; cubitus runs to apex of wing, with 10–11 branches or sub-branches to lower margin of wing; subcostal vein unites with costa before middle of wing; seven irregular, transverse branches between cubitus and radial sector.

Wing scale (of fore wing) as long as pronotum.

Legs yellow-brown to dark brown, elongate, slender, with long hairs; 3 long spines at apex tibiae, pulvillus present.

Abdomen with tergites dark brown to blackish, a row of long hairs near the base of each tergite; cerci fairly elongate.

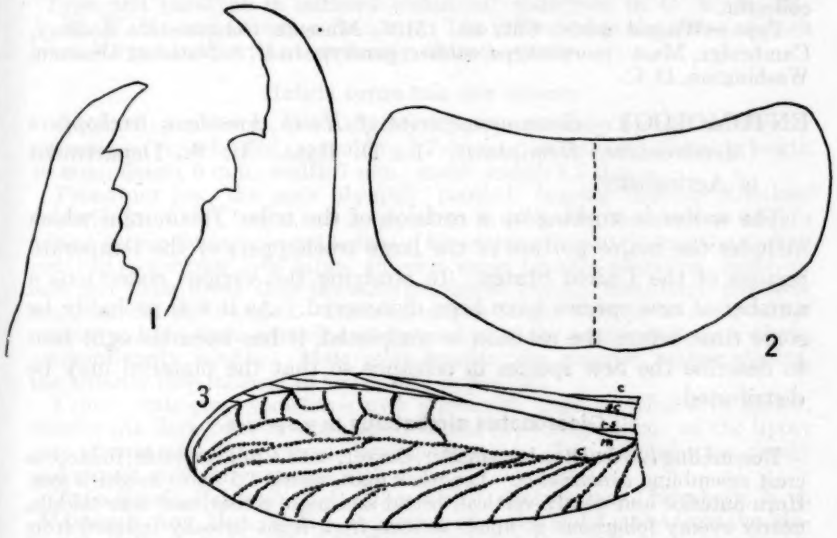
Measurements: Entire winged adult 8.5 mm. long; entire dealated adult 5.75 mm. long; head (to tip labrum) 1.55 mm. long; pronotum 0.9 mm. long; fore wing 6 mm. long; posterior wing 5.75 mm. long; hind tibia: 0.9 mm.

long; eye (long diameter) 0.305 mm.; head (at eyes) 1.4 mm. wide; pronotum 1.4 mm. wide; of fore wing, 1.70 mm. wide; posterior wing: 2.00 mm. wide.

Kalotermes (*R.*) *isthmi* Snyder is a strikingly bicolored species; *K.* (*R.*) *rugosus* Hagen is not bicolored, is larger, lighter colored, with a larger wing, and wing much less coarsely punctate.

Soldier.—Head light castaneous-brown, or yellow-brown with a reddish tinge, especially anteriorly, cylindrical, with sides nearly parallel, but broadest posteriorly, narrowed slightly anteriorly, with scattered long hairs, very dense on oblique frontal slope. Small, narrow, hyaline, slit like eye spot at right angles to sides of head.

Mandibles black, base reddish-brown, broad at base, tips slender, pointed and incurved. Left mandible with one sharp pointed marginal tooth on



KALOTERMES (RUGITERMES) ISTHMI SNYDER

Fig. 1.—Mandibles, with marginal teeth (soldier); Fig. 2.—Pronotum (soldier); Fig. 3.—Venation of fore wing. (All drawings by camera lucida; figs. 1 and 2 high power, fig. 3 low power.)

apical third, two molar teeth in middle. Right mandible with two large marginal teeth at about the middle, the first sharp pointed, the other more blunt; edge of mandible roughened between apex and first tooth (Fig. 1).

Antennae yellow, with 13 segments, slender, elongate, with long hairs; third segment light castaneous-brown, elongate, slender, subclavate, longer than second or fourth segments, nearly as long as fourth and fifth segments together; fifth slightly longer than fourth segment; segments become longer towards apex; last segment shorter, narrower and suboval.

Pronotum dirty white, tinged with yellow, margins darker, not twice as broad as long, broadest at middle, broadly, roundly emarginate anteriorly, generally convex posteriorly, sides rounded, slope (narrowed) posteriorly, with scattered long hairs (Fig. 2).

Legs tinged with yellow, femora somewhat swollen, three long spines at apex of tibia.

Abdomen dirty white, tinged with yellow, a row of long hairs near the base of each tergite, cerci elongate.

Measurements: Entire soldier 6.5–7 mm. long; head with mandibles 3.6 mm. long; head without mandibles (to anterior) 2.4 mm. long; left mandible 1.2 mm. long; pronotum 0.95 mm. long; hind tibia 1 mm. long; head (anteriorly) 1.4 mm. wide; (posteriorly) 1.6 mm. wide; pronotum 1.65 mm. wide.

Type locality.—Barro Colorado Island, C. Z., Panama.

Described from three winged adults, collected with one soldier and nymphs at the type locality "24, VII," N. Banks, collector. Other winged adults, soldiers and nymphs collected at Frijoles, C. Z., "10, VII," N. Banks, collector.

Type.—Winged adult, Cat. no. 15105, Museum Comparative Zoology, Cambridge, Mass.; morphotype, soldier; paratype in U. S. National Museum, Washington, D. C.

ENTOMOLOGY.—*Some new species of North American treehoppers (Membracidae, Hemiptera).* E. D. BALL, U. S. Department of Agriculture.

The writer is working on a revision of the tribe Telamonini which includes the major portion of the large treehoppers of the temperate regions of the United States. In studying the various collections a number of new species have been discovered. As it will probably be some time before the revision is completed, it has been thought best to describe the new species in advance so that the material may be distributed.

Glossonotus nimbatulus new species

Resembling *turriculatus* but smaller, darker, with a tall, variable, foliaceous crest resembling *acuminatus*. Length 7 mm., width 4.5 mm., height 5 mm. Horn anterior and nearly vertical, broad and high, constricted near middle, nearly evenly foliaceous at apex, as seen from front broadly inflated from just above the very short and weak lateral angles, tapering evenly to just before the apex. Lateral angles obtuse, about half the width of the eye. Pronotum moderately acute in both planes.

Color.—Uniform chestnut or darker, varying to almost black, with pale points on the sides of the horn. In the lighter specimens there is a narrow light median stripe from the apex of horn to apex of pronotum, becoming narrower in the darker specimens and occasionally wanting.

Type female, Long Island, N. Y. (Davis); allotype, male, White Mountains, N. H. (Ball); paratypes: Lakehurst, N. J. (Barber and Am. Mus. N. H.); Roselle Park, N. J.—Matausch (Am. Mus. N. H.); Framingham, Mass. (Dickerson Coll., Am. Mus. N. H.); Karner, N. Y. (N. Y. St. Coll.); and Pennsylvania (Baker Coll., U. S. N. M.).

Type and allotype in author's collection; paratypes in Davis, Barber, Am. Mus. N. H. and U. S. N. M. collections.

Heliria gibberata new species

Slightly smaller and darker than *cristata*, with the crest nearly uniform in height and only slightly overhanging. Female: length 10 mm., width 7 mm., height 5 mm.; males: length 8 mm.

Pronotum long, low, acute, weakly striated, crest prominent, situated as in *cristata* but with the posterior lobe long, almost as high as the anterior and nearly level, the anterior lobe rising in a gentle curve to the rounding and only slightly overhanging apex. Humeral angles very prominent in the female, resembling *cristata*. Males, shorter with a lower and less differentiated crest and with the humeral angles much reduced.

Color.—Pale creamy ground with irregular dark mottlings giving a grizzled appearance, these usually emphasized on anterior and posterior margins of crest, the latter often extending as an oblique stripe to costa.

Type female, allotype male, and three pair of paratypes collected by the writer at Ames, Iowa; a female from Galesburg, Ill., Stromberg (Godg. Coll.) U. S. N. M.; and one from Lincoln, Neb. (Osborn Coll.).

Type and paratype in author's collection; paratypes in U. S. N. M., A. M. N. H., and Osborn collections. The difference in the shape of both lobes of crest render this a strikingly distinct species.

Heliria cornu tula new species

Resembling *gibberata*, crest slightly longer, anteriorly upright or slightly retreating, superficially resembling *Telamona maculata*. Female: length 10 mm., height 6 mm., width 7 mm.; male: length 8.5 mm.

Pronotum low, the apex abruptly pointed, bearing definite striations posteriorly. Crest larger and longer than in *gibberata*, the anterior margin arising perpendicularly from the face of the metapodium excluding the median convexity; anterior lobe large, anterior angle broadly rounding; posterior lobe but little lower than the anterior, upper margin horizontal, posterior angle almost right-angled. Humeral angles longer than in *cristata*, rather narrow at base, then expanded and rounding to the long apices, as a whole, extraordinarily ear-like. Male crest smaller, the anterior margin sloping, the anterior lobe inclined to be broadly pyramidal.

Color.—Pale gray, sometimes with a greenish tinge, mottled with darker, usually the dark color is emphasized across the metapodium; on the upper part of crest and in two bands behind the crest. Two examples are closely and almost uniformly irrorate with dark.

Type female, Faltbush, L. I. (Olsen Coll.); allotype male, Elizabeth, N. J. (Matausch. Am. Mus. N. H.); 3 paratype females and 3 males from the Matausch Collection, Am. Mus. N. H., one labeled Bronx, N. Y., one paratype female, Hummelstown, Pa. (DeLong Coll.), and one male, Maryland (Uhler. Coll, U. S. N. M.).

Type and paratypes in author's collection; allotype and paratypes in the Am. Mus. N. H.; paratypes in U. S. N. M. and collection of DeLong.

Heliria clitella new species

Resembling *sinuata*, but with a short oblique crest and short humeral angles. Length 11 mm., width 6 mm.

Pronotum long, low, striae only normally developed and not prominent at apex. Crest shorter than in *sinuata*, anterior and posterior margins almost parallel, sloping, anterior lobe pyramidal or rounding, the posterior lobe short, the angle acute, produced. Crest with two compressed areas, one along front margin and the other parallel with it just before the posterior margin; these two troughs are separated by a very pronounced ridge that extends to the apex of the pyramid. Humeral angles very short and broad, rounding to just before the slightly acute apices.

Color.—Grizzled gray, slightly mottled with dark, without definite pattern, a broad creamy stripe arising from just below the posterior angle of the crest and extending two-thirds of the way to apex of pronotum.

Type female, and allotype male from Huachuca Mts., Ariz. (Schaffer, Brooklyn Mus.); paratype female taken with the types (Woodruff Coll.), and a male from Arizona (Cornell Coll.)

Type in author's collection; allotype in the Brooklyn Museum; paratypes in Cornell Collection and collection of L. M. Woodruff.

Heliria fitchi new species

Resembling *sinuata* but with a lower crest and a more definite "step." Length 11 mm., width 6 mm.

Pronotum very long, striae normal, crest moderate, placed well back of metapodium, intermediate in length between *sinuata* and *clitella*, anterior margin quite sloping, posterior margin vertical, anterior lobe almost uniformly rounding above, one-third higher than the posterior one, posterior lobe almost square. Humeral angles very short for this group, slightly acutely angled with the margin rounding.

Color.—Pale creamy with quite definite dark mottlings, as follows: most of the crest including an oblique band to the costa, a spot on the costa before this and most of the apical region of pronotum. The oblique stripe and the apical markings are separated by a white band which is enlarged on the median line and contains a definite dark spot. One example is much darker than the others and the old examples are pale brown rather than creamy.

Type female, allotype male, and one paratype female, Charter Oak, Pa. (DeLong); paratype male, New York (Fitch Coll., U. S. N. M.) and another labeled "city" (Uhler Coll., U. S. N. M.), probably from Baltimore, Md.

Type female and allotype male in author's collection; paratypes in U. S. N. M. and DeLong's collection.

This is a strikingly distinct species although closely related to *sinuata* and *clitella*. The examples from the Fitch collection in the National Museum are labeled *Telamona concava* Fitch and one parasitized example, probably a female, is labeled "type." This is not the species represented by the Fitch type in the Albany collection as will be discussed in a later paper.

Heliria gemma new species

Resembling *fitchi* but paler and with a less definitely sinuated crest; crest intermediate between that of *fitchi* and *concava*. Large; female, light creamy with brown mottlings; males brown, hairy; crest long, broadly pyramidal with a posterior sinuation or step. Length, female 11 mm., width 5.5 mm., height 5.5 mm.; male, length 8–9 mm.

Pronotum long, acute, crest arising just back of the metapodial slope, anterior margin sloping insensibly into the outline of the rather large broadly rounding anterior lobe, posterior lobe short, sometimes almost merged into the posterior slope of the anterior one, usually represented by a slight step or sinuation, the posterior angle obtuse and the margin rounding into the posterior process. Humeral angles very broad, about right-angled, equaling or exceeding the breadth of the eye.

Color.—Female pale creamy, irregularly irrorate and mottled with brown, the brown mottling emphasized on the crest, the oblique stripe and at the apex of pronotum, the creamy emphasized in a semicircle beneath the crest on

either side and a band behind the crest which is connected with a definite white stripe on the posterior face of crest. The semicircles are irregular along the margin with brown mottling along the lower border and a tooth of light pushed up into the anterior base of the crest. The males are densely hairy, almost uniform brown, with traces of the creamy tooth and the posterior stripe.

Type female, Vermont (Barrett); allotype male and two pairs of paratypes, Adirondack Mts., N. Y. (Barber); paratype females, Catskill Mts., N. Y. (Wanakana, N. Y. (Osb. Coll.); Lancaster, N. Y. (Van D. Coll., Ames); New Hampshire and Massachusetts (U. S. N. M.); and males, Elk Park, N. Y. (Drake); and Mt. Katahdin, Me. (Barber).

Types, allotype, and paratypes in author's collection; paratypes in U. S. N. M., Am. Mus. N. H., Ames Coll., Osborn Coll., and Barber Coll.

Telonaca tremulata new species

Resembling *pyramidata* slightly shorter, stouter, with a broader sloping sinuate crest and much darker pigmentation. Length, female 9–10 mm., with 5.5. mm., height 5 mm. Length, male 8 mm.

Pronotum stout, the apical process rarely as long as the elytra, with a long pyramidal crest sloping from the metapodium to the anterior angle with a slight sinuation; anterior angle almost a right angle; top of crest long, sloping, concave, slightly sinuate, posterior angle obtuse, the posterior margin sloping slightly less than the anterior.

Numeral angles prominent, similar to *pyramidata*, not as long as their basal width, scarcely equaling the eye in length, slightly acutely angular, the apex rounded.

Color.—Variable, usually soiled yellow, so heavily irrorated and mottled with dark fuscous as to give a general dirty grizzled appearance with still darker areas on the crest and extending obliquely to the costa as well as at the apex. The males are usually darker, sometimes with a brownish shade. The Utah examples are pale creamy with definite dark markings in sharp contrast

Type male Ephraim, Utah, July 20, 1924; allotype female Salem, N. Y., July 27, 1924, both collected by the writer on aspen. Paratypes: Woodruff, Wisc. (DeLong); Bayfield, Wisc., (Wickham, Barber Coll.); Osceola, Wisc. (Ball); Cranberry lake, N. Y. (Osborn); Canada (Baker, U. S. N. M.); Buena Vista, Colo. (Wickham); and Colorado (Baker, U. S. N. M.).

Type and allotype in author's collection; paratypes in Barber, Osborn, DeLong, Am. Mus. N. H. and U. S. N. M. collections.

Telamona tiliae new species

Intermediate between *spreta* and *reclivata* in outline, resembling *spreta* but with definite dark markings especially in the male. Length, female 10 mm., width 6 mm., height 5 mm. Length, male 9 mm.

Pronotum long, acute, crest broad, quadrangular, inclined posteriorly, the anterior margin sloping from middle of metapodium to middle of crest, crest obliquely truncate, the anterior angle roundingly rectangular, the posterior one obtuse, posterior margin upright, rounding into pronotum below. Humeral angles slightly obtusely angular, their margins curved, almost equaling the eye.

Color.—Dirty grayish-green, fading to dirty yellowish, with most of the crest and an oblique strip to costa brown; in the females this brown area may

only be emphasized on the margin but in the males it is broad and definite, a broad light stripe on anterior and posterior margins of crest.

Type female and allotype male, Ames, Iowa. Two pairs paratypes, Ames, Iowa, and two pairs, Milwaukee, Wisconsin, all collected by the writer on basswood. Type in author's collection; paratypes in author's collection, Am. Mus. Nat. Hist. and U. S. Nat. Mus.

Telamona gibbera new species

Resembling *tiliae* but smaller and differently marked, slightly larger than *reclivata*, with a taller, narrower crest. Length, female 9 mm., width 5 mm., height 6 mm. Length, male 8 mm.

Pronotum low, rather broad with a narrow upright crest arising well back of the metapodium. Crest with the anterior margin vertical and in line with the lateral angles; dorsum obliquely rounding, highest just back of the anterior margin and sloping down to the obtuse posterior angle, posterior margin slightly sloping and rounding into the broad apical portion; humeral angles broad, almost right angles, equaling the eyes, resembling *tiliae*. Male slightly smaller than the female with the crest sloping equally from both front and back.

Color.—Dirty gray, slightly darkening around the margin of crest and set off by a white stripe on the posterior slope. Male highly and strikingly ornamented, as follows: Face and metapodium irregularly mottled with brown; crest heavily margined with dark brown with occasional light spots, a creamy area below the crest on either side which sends up a narrow yellow stripe into the dark of the crest, anterior carinae narrowly light and posterior slope broadly so.

Type female, allotype male, and 3 paratype females, Williams, Ariz. (Knight); 1 paratype female, 1 paratype male, Pinal Mts., Ariz. (Wickman Ames Coll.); 2 females, Williams, Ariz.; and 1 female and 2 males Flagstaff, Ariz. (Barber and Swartz); 1 female and 3 males, Chiric. Mts., Ariz. (Hubbard)—all U. S. N. M. Type and allotype in author's collection; paratype in collection of author—H. H. Knight, Ia. St. Coll., Kan. U., U. S. Nat. Mus. and Am. Mus. N. H.

Telamona tarda new species

Resembling *gibbera* but with a slightly more anterior and pyramidal crest. Length, female 8.5 mm., width 4.5 mm., height 5 mm. Length, male 7 mm.

Pronotum long and acute, about five lateral carinae strongly developed back of the crest as in *woodruffi;* crest arising only slightly back of the metapodium, anterior margin slightly sloping from the metapodium to just before the evenly rounded apex; apex about one-half the width at base, posterior margin more sloping than the anterior, its outline almost straight to where it rounds to the pronotum. Humeral angles very short and rounding, one-half the length of the eye. Male very small, hairy, with a low rounding crest sloping equally from both margins.

Color.—Pale dirty grayish-brown with slight darkening of the margins of the humeral angles and crest; median carina black interrupted before and behind the crest with light. Male darker with the crest mottled brown.

Type female and allotype male, paratype female and male, Roselle Park, N. J. (Matausch Coll., Am. Mus. N. H.); type and paratype Am. Mus. N. H.; allotype and paratype and in author's collection.

Telamona woodruffi new species

Resembling *compacta* but with a slightly higher and more angular crest as in *reclivata* and less maculations. Length 8 mm., width 4 mm., height 5 mm.

Pronotum rather high, crest broader than high, slightly inclined posteriorly, dorsum long and straight, both angles rounding. Anterior margins sloping more than posterior and about in line with the humeral angles. Humeral angles roundingly right-angled, almost equaling the eye, much longer and more acute than in *compacta*. About five lateral carinae, quite definitely marked on the apical portion of the pronotum. Male with a smaller crest sloping into the metapodium anteriorly.

Color.—Rich, red-brown with occasional white flecks, much smaller and more obscure than in *compacta*. Carina interruptedly dark, posterior slope of crest light with dark margins. Male darker.

Type female and allotype male, Elizabeth, N. J. Three-paratype females and one male from the same locality. All from the Matausch Coll., Am. Mus. N. H. Type in Am. Mus. N. H.; allotype and paratype in author's collection, paratypes in Coll. Am. Mus. N. H. and L. M. Woodruff. Named for Mr. L. M. Woodruff who has done such fine work on the genus *Cyrtolobus*.

Telamona vestita new species

Resembling *monticola*, slightly smaller, darker, and with the crest rounding over from the metapodium almost to the posterior angle. Length, female 9 mm., width 5 mm., height 6 mm. Length, male 8 mm.

Pronotum rather broad and short, crest very broad occupying nearly one-half the pronotum, anterior margin arising as a continuation of the curve of the metapodium and rounding over to the elongate dorsum; posterior margin short, upright, the angle often slightly acute. Humeral angles more prominent than in *monticola*, right-angled, equaling the eye.

Color.—Pale, dirty yellowish, slightly flecked with brown, a light area on the posterior face of crest. The males are much smaller and darker and the Oregon female is dark.

Type female and allotype male, Quincy, Calif. Paratype females from Quincy and Salinas, Calif. and a male from Tehachapi, Calif. all collected by the writer. One female, Oregon (Westcott); 2 males, Gold Hill, Oregon (Biederman, U. S. Nat. Mus.); 1 female Humboldt, Calif. (VanDyke, U. S. Nat. Mus.); and a male, Santa Cruz Mts., Calif. (U. S. Nat. Mus.). Type and allotype in the author's collection. Paratypes in National Museum, the American Museum of Natural History and the author's collection.

This is a very distinct species resembling *monticola* but lacking the green color. It is close to *reclivata* in structure but has a higher crest.

SCIENTIFIC NOTES AND NEWS

Public law No. 353, 68th Congress, approved January 31, 1925, reads as follows: "Be it enacted . . . . That the Coast and Geodetic Survey is hereby authorized to make investigations and reports in seismology, including such investigations as have been heretofore performed by the Weather Bureau." The *Bulletin* of the Survey announces that publication of seismological reports formerly published by the Weather Bureau in the *Monthly Weather Review* and discontinued July 1, 1924, will be resumed in the near future. The Act will have the effect of placing the seismological work of

the Survey, which has heretofore been an adjunct to the magnetic work, in a position of equal importance to the magnetic work..

The Petrologists Club met at the home of A. C. SPENCER on March 17. Program: J. W. GRIEG: *The decomposition of andalusite, kyanite and sillimanite by heating;* R. W. G. WYCKOFF: *X-ray diffraction measurements on sillimanite and mullite;* A. C. SPENCER: *Review of Spurr and Lewis' "Ore deposits of Franklin Furnace."*

The Petrologists Club met at the home of H. G. FERGUSON on April 14. Program: J. B. MERTIE, *An outline of the igneous geology of Alaska;* W. T. SCHALLER: *Red muscovite from New Mexico;* D. F. HEWETT: *Supergene silica and jarosites in Nevada.*

A joint meeting of the Washington sections of the American Society of Mechanical Engineers, American Society of Naval Engineers and American Chemical Society, with the Washington Society of Engineers, was held on April 23 to hear a lecture by E. C. MAGDEBURGER on *Diesel engines in submarines.*

The April meeting of the Pick and Hammer Club was devoted to a discussion of the application of aerial photography to topographic and geologic mapping.

An illustrated lecture on Bird life in the District of Columbia was given by HARRY C. OBERHOLZER before the Columbia Historical Society on April 21.

The ACADEMY'S *List of one hundred popular books in science,* prepared originally at the request of Dr. G. F. BOWERMAN, Librarian of the Public Library, and subsequently republished by the American Library Association, is now out of print, several thousand copies having been sold. The Association wished to reprint the list but has postponed reprinting for a few weeks in order to give opportunity for any revision that may be thought desirable. A committee consisting of the vice-presidents of the ACADEMY, with R. B. SOSMAN of the Geophysical Laboratory as chairman, has been appointed to prepare this revision. Suggestions from readers of the *Journal* as to desirable changes will be appreciated by the committee. The latest revision was published in this *Journal,* Vol. 12, p. 469, (Dec. 19, 1922).